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Biography

Colonel Joel Jackson is a student at the Air War College and a command pilot with over 5,000 hours in the KC-10A. He has commanded at the squadron level and worked on the staff of the United States Transportation Command where he integrated multiple transportation modes to complete the factory to foxhole mandate as the transportation distribution process owner.

INTRODUCTION

Since the beginning of Operation ENDURING FREEDOM, Department of Defense investment in unmanned aircraft systems (UAS) has exploded almost 700% to just under $4 billion per year in 2009.[1] This expansion was caused by the successful application of UASs primarily in their role as intelligence, surveillance, and reconnaissance (ISR) platforms, but also as ISR/strike platforms because these particular mission sets fit the capabilities of UASs. Going forward with these successes, the Department of Defense (DoD) should assess potential future UAS missions by first determining what particular characteristics of the ISR and ISR/strike missions made them successful as UAS missions and then determining what other missions fit these same characteristics. Emergency and mission-critical, time-sensitive (MCTS), intra-theater logistical resupply are missions which fit these characteristics of being advantageous to persistent, efficient, modular systems integrated into a pervasive battle space. Work is currently underway developing UASs to accomplish these missions, but these current applications do not focus on these specific characteristics. Instead a UAS designed specifically as a logistical delivery platform with modular ISR/strike capabilities and long endurance should be developed to fill these missions.

INTRA-THEATER RESUPPLY IN CENTRAL COMMAND

Intra-theater resupply is conducted within a single geographic theater. This type of resupply, often called "the last tactical mile," generally goes from forward supply bases out to the troops in the field. The amount of supplies required for a deployed Army or Marine unit throughout a theater are well defined. The Marine Corps, for example, states a requirement of 20,000 pounds of supplies per day per company for Afghanistan. The Army, similarly, states a requirement of 7,280 pounds per day per platoon or 170 pounds per day per person.[2] This

resupply, however, may be broken down into classes and categories. The classes of supplies are groups such as food and water (Class I), fuels (Class III), ammunition (Class V), and repair parts (Class IX). Class I consists of 53 percent of the daily requirement and Class V adds another 6 percent.[3] Resupply can also be broken into three categories: emergency, MCTS, and routine.

Simply put, emergency resupply is the delivery of supplies which if not immediately received will cause a unit catastrophic consequences.[4] MCTS resupply, on the other hand, is the delivery of those supplies needed on short notice or outside the normal resupply system.[5] What exactly is considered MCTS varies from commander to commander, but in general, it is any commodity needed to maintain operational effectiveness. This definition is broad enough that it can include anything from a 2,000 pound generator to 100 pounds of ammunition, but in Afghanistan, food and water were added to the MCTS priority list[6] with class I, III (small quantities), V, and IX being the most common classes flown as MCTS.[7] Implied with MCTS resupply is the requirement to be delivered in a timely manner. The generally accepted length of time for the MCTS supply system is 24 hours from request to delivery[8] compared with 72 hours for supplies considered routine.[9] Routine intra-theater supply has traditionally been accomplished by ground delivery with emergency and MCTS supply accomplished by fixed-wing aircraft to forward airstrips, but both of these methods have proven to be incompatible with the ongoing operations in Afghanistan.[10]

The cheapest method of delivery, truck, met resistance in Iraq with the proliferation of improvised explosion devises (IEDs). Since 2003, the goal of theater commanders has been to mitigate this threat by decreasing truck convoys and increasing the movement of supplies by air.[11] In Afghanistan, the IED problem has been exacerbated by poor transportation infrastructure. While 84% of roads in Iraq are paved, only 29% of roads are paved in

Afghanistan.[12] These two factors contributed to the desire to move as little resupply over land as possible. Unfortunately, the other common delivery method, using air assets to locations with landing strips, is also not practical in Afghanistan. While this method is achievable to some locations, the general lack of landing strips where the units need the supplies has resulted in the inability to deliver a large amount of goods by traditional airlift methods.[13] Furthermore, the Army has terminated use of its C-23 Sherpas in Afghanistan. Historically they have used these aircraft to move small, MCTS cargo to forward troop locations, but the Sherpa lacks the performance capabilities to operate in the high altitudes required in Afghanistan.[14] This inability to employ fixed wing assets using traditional airlift methods has dramatically increased the use of airdrop delivery and rotary wing aircraft to meet resupply requirements.

Unfortunately, the increased use of airdrop and rotary wing assets to support resupply has resulted in some new challenges. First, the current inventory of rotary wing aircraft has been stretched too thin. The primary mission of the CH-47 is to aide the air assault of dismounted combat forces,[15] but by using them as resupply tools, the Army and the Special Forces Command do not have enough aircraft to perform their primary missions. In addition, the long flights associated with the vast distances between supply bases, outposts, and available fuel bases in Afghanistan add “substantial wear and tear”[16] to the CH-47s and UH-60s used to perform resupply missions. This in turn, adversely affects the aircrafts’ maintainability rates, further decreasing their availability for any mission. To alleviate some of this shortfall in helicopter availability, the Army increased their CH-47 fleet by 11% in 2005.[17] Furthermore, in April 2010, the Deputy Assistant Defense Secretary for Special Operations and Combating Terrorism announced the FY11 budget would include money for the special operations community to procure eight MH-47Gs from the Army, purchase 16 new MH-60Ms, and buy five additional

CV-22 aircraft; all specifically for use by special forces.[18] Purchasing new rotary wing aircraft obviously increases availability, but even if there are enough rotary wing assets to go around, using them for logistical operations is simply inefficient.

While the initial purchase cost of the CH-47 and UH-60 can be significantly less than the C-130J or C-27J (the C-27J is in procurement to replace the C-23), the operating costs of the UH-60 is approximately equal to a small fixed wing aircraft such as the C-23, C-130J, or C-27J. Furthermore, CH-47 operating costs are four to five times that of these fixed wing aircraft.[19] In fact, when comparing the increased lift capacity fixed wing aircraft have over rotary wing aircraft, using the cost to transport tons per mile over long distances as the comparison metric, the CH-47 is ten times more expensive to operate than the C-27J.[20] In addition, current Army tactics in Afghanistan dictate all helicopters are always used in pairs, regardless of the mission. This restriction can double the cost per ton-mile because each mission requires the use of two aircraft, regardless of the scheduled cargo. General Dynamics conducted a study in 2010 quantifying the total cost per pound to deliver goods via helicopter and fixed wing aircraft in Afghanistan specific scenarios. Their study included many variables including aircraft availability, weather cancellation rates, personnel per aircraft, operating costs, and projected loss rate per aircraft. They determined the cost per pound moved was always least for the C-27J, closely followed by the C-130. A distant third in all scenarios was the CH-47 and the most expensive per pound moved was the UH-60.[21] Not only is the cost of using rotary wing aircraft for intra-theater resupply high because it takes valuable assets away from their primary mission, it is also an inefficient method of providing resupply over the distances required in Afghanistan. Due to these high costs, a 2010 RAND study recommended the use of fixed-wing aircraft for longer resupply flights, specifically advocating fixed-wing aircraft with the use of "JPADs to

deliver emergency supplies to FOBs [forward operating bases] and COPs [combat outposts] when the ground situation so requires."[22]

Because of the high costs associated with using rotary wing assets to resupply in Afghanistan, the bulk of the routine resupply has been accomplished cheaper by C-130 and C-17 aircraft. Along with direct delivery to those locations with landing strips, these aircraft have been airdropping almost 1,000 bundles per week at an average weight per bundle of 1,700 pounds. Because of their size, these aircraft are able to do airdrops in large quantities. For example, a C-17, drops between 25 and 30 bundles while the C-130 delivers 10 bundles per flight.[23] By airdropping large average payloads, these aircraft operate very efficiently, but there is a severe disadvantage to using large aircraft. Since they are in high demand to deliver large quantities of equipment, personnel, and supplies by air, there is a very structured scheduling system based on a 72-hour validation process and formalized priorities. This system was developed to make the delivery of goods as efficient as possible while maximizing the effectiveness for all users. Even with requests for important movements such as emergency airdrop or MCTS, however, it still takes General Officer intervention to validate supplies for delivery inside the 72 hour validation window.[24] Once the goods have been validated for delivery, it still takes between 6 and 24 hours, depending on aircraft availability and mission importance, for the supplies to be made airworthy and loaded for delivery.[25] Once airborne, the aircraft still must travel the distance from the supply base to the troops requesting the supplies. Finally, depending on the priority of the supplies, this time critical delivery could preempt the use of a mobility asset from servicing multiple users to provide the single important shipment. While this capability is effective in meeting the warfighter's requirement, it is usually an inefficient use of a fixed wing asset. By contrast the Army's entire scheduling system for their

aircraft is developed to respond within 24 hours enabling small tactically sized resupply to fielded troops. In Afghanistan these two scheduling systems have resulted in resupply delivery that can either be responsive to the troops in the field by delivering emergency or MCTS items within 24 hours of request but at the cost of either diverting rotary wing assets from their primary mission with General Officer intervention or a system that can efficiently deliver goods using fixed wing assets but with a long request validation time of up to 72 hours.

These options are not good enough for our fielded troops. In August 2007, Combined Joint Special Operations Task Force – Afghanistan (CJSOTF-A) published a memorandum back to United States Special Operations Command detailing the requirement for better emergency resupply. CJSOTF-A outlined the need for a more responsive system to resupply troops in contact (TIC) with the enemy with emergency ammunition, medical supplies, fuels, and water; primarily classes I, III, and V. For this mission, they request a UAS capable of delivering a minimum of 1,000 pounds accurately within 150 meters of the TIC in "high and hot" environmental conditions, i.e., mountainous areas and hot temperatures.[26] While CJSOTF-A specifically requested a UAS for this mission, it is first important to understand what mission types lend themselves to this air platform.

CURRENT UASs

Both RAND and General Dynamics conducted studies in 2010 characterizing the likely mission types for UASs using the three "Ds": dull, dirty and dangerous. While the "Ds" are a catchy way to discuss the missions advantageous to UASs, the U.S. Air Force in the 2009 UAS Flight Plan explains it better.   The Flight Plan says "UAS[s] are compelling where human physiology limits mission execution (e.g. persistence, speed of reaction, contaminated environment)."[27] It then expands on this, specifying the attributes UASs will capitalize on as

"persistence, connectivity, flexibility, autonomy, and efficiency."[28] It goes on saying UASs must be integrated with manned and other unmanned systems to increase capabilities across the full range of military operations. They also must be automated to perhaps lower cost, footprint, and risk. Furthermore, they should have a final outcome of a vehicle with a modular system of capabilities and not a particular platform for one mission.[29] In summary, there is a significant niche these missions should fill and the more niches each platform can fill the better. The Flight Plan does not assume UASs will be developed to replace manned aircraft unless there is a compelling reason in either a mission niche capitalizing on inherent UAS attributes or efficiencies gained by adopting a UAS system. The success of the current large ISR platforms follows these Flight Plan attributes and fit this niche.

The U.S. Air Force and the rest of the DoD has many small UASs used for reconnaissance. The mission of logistical distribution lends itself to larger systems in order to fit supplies; therefore this paper will only use the DoD's large ISR platforms for comparison. The DoD has two primary large ISR platforms and one large strike/ISR platform: the RQ-4, the MQ-1, and the MQ-9. The MQ-1 Predator is the work horse of the current ISR UAS fleet. As the M denotes in the name, it is a multi-role aircraft versus the reconnaissance only RQ-4. The MQ platforms are primarily low-altitude ISR platforms capable of performing close air support (CAS), combat search and rescue (CSAR) support, and precision strike all during an ISR mission. The Predator has a max payload of 300 pounds and can loiter for 22 hours at speeds of up to 135 knots.[30] The MQ-9 Reaper is a larger platform capable of performing the same roles as the Predator, but has an increased payload and speed capability compared to the MQ-1. The increased size of the platform expands its payload to 3,000 pounds but limits endurance to 18 hours at speeds up to 200 knots.[31] The RQ-4 Global Hawk is the largest of the three UASs with

a commensurate increase in both payload and endurance. It is purely a high-altitude ISR platform incapable of an attack mission, though it is capable of a wide array of ISR tasks. Its size gives it a 3,000 pound payload as well as an endurance of 28 hours at speeds over 300 knots.[32] To determine other missions which may be right for UASs, it is important to understand why these three platforms have been successful in their missions. First, these three platforms fit exactly into the niche mission and efficiency construct of the U.S. Air Force Flight Plan. Second, they have been deployed in an environment void of regulatory or enemy constraints.

As previously noted, the Flight Plan described assumptions for the future use of UASs. These assumptions included mitigating the limitations of human physiology while maximizing flexibility and efficiency. Due to their long endurance capabilities, these platforms are able to persist, or maintain operational status, over the battlespace for extended periods of time. They specifically have the characteristic of persistence because they are not constrained by the physiologically-based flight duty times associated with manned aircraft. Since the primary mission of these UASs is ISR, a major criterion for success is duration over the survey area. Unlike missions requiring the movement from point A to point B, these missions simply require persistence over a desired area. Finally, the natural evolution of this persistent mission was adapting munitions to the airframe, resulting in a concurrent attack capability.

These three UASs possess other advantages based on the Flight Plan. They have modular systems integrated into the entire battle space construct with complementary manned and unmanned vehicles. By the word modular, the Air Force implies the ability to mix and match payloads to attain desired capabilities. All three UAS platforms offer complete flexibility to fill a variety of roles depending upon warfighter requirements. The Air Force also integrates the current UASs by using manned, unmanned, and satellite technology when conducting theater

ISR as well as manned and unmanned strike aircraft. This combination of modular assets gives the war fighter complete flexibility of capabilities and applications to use depending on the circumstances.

The second aspect to consider in determining why the ISR platforms have been successful is cost. While cost is always important and seems to be listed as a UAS advantage in any study, the Flight Plan only assumes the automation of UASs could *potentially* reduce costs.[33] While none of the current ISR platforms can be considered cheap, they either fill a niche mission and are thus fiscally incomparable, or they are significantly cheaper than their manned counterpart. The cheapest platform is the Predator which has a cost of $20 million, in 2009 dollars, for each set of four aircraft, ground control station, and satellite link.[34] The Reaper steps up to a cost of $53.5 million, in 2006 dollars, for a set of four aircraft[35] while the RQ-4 has the highest per unit cost of between $55 and $81 million per aircraft.[36] What is significant for these UASs, however, is their cost compared to manned systems. While the Predator at only five million dollars per airframe has no comparable manned aircraft, the Reaper could be compared either to the legacy strike aircraft, the F-16, or the new strike aircraft, the F-35, both of which are considerably more expensive. While the F-16 costs $23 million in 2006 dollars, only twice as much as the Reaper, it is beginning to be phased out the inventory due to its increasing age and maintenance costs. The F-16's replacement, the F-35, on the other hand, is currently estimated to cost approximately $120 million in 2010 dollars, or almost 10 times more than a Reaper. Finally, while the Global Hawk is the most expensive UAS, the cost of its closest manned counterpart, the U-2, is still classified. Additionally, UASs also have cheaper operating costs. While acknowledging the source of this information is Northrop Grumman, the manufacturer of the Global Hawk, the stated costs of operating the Global Hawk is quoted as one-third that of the

U-2[37] with similar lower operating costs being the case for the Predator and Reaper as well. Beyond just looking at these lower costs, however, is understanding why UASs are cheaper.

One of the main criteria for the lower acquisition and operating costs over their manned equivalent is the extra cost associated with building an environment for a human. Aircraft cost is directly proportional to weight and aerodynamic shape. Each extra pound built into the aircraft requires added lift to get airborne and each reduction in aerodynamic shape increases drag that must be overcome driving costs associated with the design and operation up. A Stanford University study based on a summary by R.S. Shevell breaks out these costs for the different components of an airliner. While this is not a direct comparison to a fighter or reconnaissance aircraft, it does give a significant factor worth considering. This study attributes weight directly to both manufacturing and operating costs and then attributes over 28% of the weight of an airliner to the climate control system, avionics, and navigation systems associated with having human pilots.[38] As such, any UAS system trying to achieve cost supremacy over a manned system should be designed purely as an unmanned system from the start. Any "optionally manned" UAS drives higher acquisition and operating costs.

There is more to cost, however, than simply the acquisition and hourly operating cost of the platform. Another important aspect of overall cost is the cost associated with the personnel required to operate the aircraft. There are three important aspects to consider in personnel costs--the number of people required to operate and pilot the aircraft, the cost to train the pilots, and the number of aircraft each crew can operate at a time. While the Air Force has not fully decided how all UAS pilots will be trained, the current plan is to develop pilots by sending them to specialized remotely piloted aircraft training (RPA) and not specialized undergraduate pilot training (SUPT). This decision is driven by both the long timeline and high cost of SUPT. To

send one pilot to SUPT costs the Air Force $888,900 and takes approximately one year plus follow-on specialized aircraft training which often takes six months to a year to complete. RPA training costs the Air Force $32,800 per student and takes only ten months from the beginning of training until they are qualified to fly combat missions.[39] A second cost advantage to the current UASs is the number of missions each operator can fly concurrently. Due to the generally simplistic loiter-type mission these aircraft fly and the automation associated with the aircraft's technology, two pilots are generally used to operate three missions and occasionally run four separate missions concurrently. These advantages drastically lower both the personnel and training costs associated with these ISR UASs.

Finally, ISR UASs are successful because they operate in a friendly regulatory environment as well as an environment free from air-to-air enemies. Current airspace regulations by both the Federal Aviation Administration (FAA) as well as the international equivalent, the International Civil Aviation Organization (ICAO), put tight restrictions upon UASs operating in airspace with manned aircraft. In 2006, the FAA issued a certificate of authorization granting Predators and Reapers access to US civilian airspace in order to search for survivors after disasters, but this allowance is narrow and currently the exception rather than the rule. Until technology solves the dilemma of how UASs avoid collisions with manned aircraft, whether the manned aircraft is equipped with traffic collision avoidance systems (TCAS) or not, UASs will not have access to regulated airspace. This restriction drastically limits the missions UASs can train for and fly. Lastly, if the US did not have air supremacy over Afghanistan, it would severely limit the success of these UASs due to their lack of defensive systems. While the ISR UASs have been very successful in Afghanistan, it is not for one particular reason but a combination of various reasons. To determine other potential missions for UASs, there must be

an evaluation of these missions against the same factors that capitalize on the current UASs' strengths.

FUTURE UAS MISSION

To be truly successful, any new UAS should meet a niche mission, meshing with the inherent advantages of a UAS and be cost effective. In stating the current problems with emergency and MCTS supply delivery, General Dynamics defined one challenge as needing the flexibility to respond to changes in the operational environment. The two factors they determined account for the responsiveness of a logistical system are the distance-terrain interaction and the planning cycle time leading up to mission execution.[40] Both these factors are generally predetermined. The location of the supply depot is usually fixed, and the distance required to travel is determined by the location of the troops. While the planning cycle can be sped up thru General Officer involvement in the validation phase or a complete process improvement of the planning cycle, it is currently fixed at either 24 or 72 hours as discussed earlier. If the advantages of UASs are exploited, however, UASs can overcome both of these shortcomings.

The current assumption in resupply is people request goods that are then loaded on a resupply vehicle and taken to the point of need. Conceptually, this is akin to waiting until troops in contact request air support prior to loading the weapons on the aircraft and then working the mission into the planned events. While this business model works fine for low priority, noncritical goods, it does not work well for emergency/MCTS requirements. To meet the needs for these critical supplies, they need to be available and ready for delivery when requested by the user. Also, in today's combat environment, a unit may not know in advance when it really wants goods delivered. What may now seem to be a good time to receive supplies may rapidly become

a bad time 24 hours later. A goal of the logistical system should be to minimize the lead time from request to delivery of these critical emergency/MCTS requests by reducing both the distance-terrain interaction as well as the planning cycle while maintaining effectiveness for the receiving unit. In order to accomplish this task, an RPA preloaded with approximately 1,000 pounds of common emergency/MCTS cargo along with modular ISR packages could maintain long loiter times over the battlefield, providing ISR coverage until called in by units in need of the supplies. The RPA could then either use low-cost, low-altitude (LCLA) airdrop or joint precision airdrop systems (JPADS) to deliver supplies before returning to its ISR orbit, awaiting relief by the next cargo-loaded RPA. As the Air Force is planning on providing 50 ISR UAS orbits by 2011,[41] the proximity of these orbits to the units in need of supply should be close, reducing the time from request to receipt and providing the goods when and where desired.

While prepositioned logistics cannot account for every type of critical delivery requirement, the most common requests can be accommodated. Of the top five classes of short notice requests determined by the General Dynamics study[42] only Class IX, repair parts, could be hard to preplan into standing cargo loads. Class I, food and water, Class V, ammunition, Class VIII, medical supplies, and Class III, petroleum products, could all have prepositioned stocks ready for delivery. By taking some of the most common requests out of the current delivery system and into this niche delivery capability, it would also reduce the drain on the current system.

While airlift is inherently expensive and loitering with cargo is not within the normal thought process of how to efficiently provide airlift, the mixture of ISR/CAS and resupply missions coupled with the added effectiveness of the instantly deliverable emergency supplies added to an otherwise lightweight efficient RPA make the costs of loitering with additional cargo

acceptable. New technologies are already emerging to lower the weight of aircraft reducing the overall weight increase. The new advanced composite cargo aircraft (ACCA), for example, is a flying test bed aircraft designed to test new cheaper and easier methods to integrate composites into aircraft. By integrating these new capabilities with the cost efficiencies of training RPA pilots separately from manned aircraft pilots and using new technologies allowing up to a 4:1 airframe per pilot ratio, the added effectiveness of instantly deliverable emergency or MCTS goods will far outweigh the costs. The United States Transportation Command (USTRANSCOM) recently let a $450 million dollar, 5-year contract for manned civilian rotary wing lift in Afghanistan.[43] While the cargo UASs would not be able to fill this entire mission set, it could provide a cheaper and better response to the customer for the right mission niche.

RECOMMENDATION

Currently, there is only one UAS with similar capabilities to partially fill this mission, the Boeing A160, but even it does not possess all the required capabilities to truly capitalize on the UAS strengths. The A160 is an $8.5 million dollar rotary wing aircraft, specifically designed to be an unpiloted UAS capable of providing all-weather vertical takeoff and landing delivery of goods with payloads of about 1000 pounds and endurance of about 18 hours.[44] Unfortunately, while the A160 does have a long endurance capability, it is at the expense of cargo weight. While maintaining 18 hours of endurance, its cargo capability reduces to only 300 pounds, negating the ability for it to load ISR modules on board during its loiter time. Some advantages the rotary wing A160 has over a potential fixed wing cargo UAS are the ability to provide all-weather precision delivery using vertical takeoff and landing (VTOL) as well as the ability to bring back people or cargo after making a delivery. The General Dynamics study, however, estimates only a 3.4% weather delay rate for fixed wing aircraft providing low-altitude air-

drop[45] and that airdrop using LCLA bundles would meet the needs of half of the resupply precision requirements.[46] This 50%, however, includes the delivery of large quantities of fuel and water that are still being delivered by ground convoy. So while goods occasionally do need to be delivered with the precision only a VTOL aircraft can attain, LCLA is able to cheaply provide the accuracy required for the vast majority of supplies while JPADS has recently improved its accuracy providing pin-point delivery at a higher price if this trade off is desired by the user. Also, one of the benefits of the A160 is the ability to hover and not land when delivering goods as to not require a landing zone. By capitalizing on this capability, however, it negates the ability to carry return goods or passengers. So while the A160 meets some of the requirements to maximize its strength as a UAS, it is not able to fully capitalize on all of the advantageous laid out by the AF Flight Plan. To truly capitalize on these strengths, a fixed wing aircraft, specifically designed as a UAS, with the ability to airdrop 1,000 pounds on standard pallets and hold an ISR array, all while having a 24-hour loiter time, should be developed.

CONCLUSION

The is no doubt ISR UASs have been successful in Iraq and Afghanistan and there can be equally no doubt troops in Afghanistan are in need of an emergency and MCTS resupply system capable of delivering goods as soon as possible after they have been requested. While it may be a short term gain to simply design a non-piloted version of a current rotary wing aircraft or make an evolutionary step forward by designing an new rotary wing UAS for this single mission, unless all the tenets of the AF Flight Plan are enacted and a fully modular system is designed capitalizing on the persistent capabilities of the UAS, the DoD will be failing to fully meet the potential for an intra-theater resupply UAS.

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